-continued

ARSTH3	Air	No	2.63	SLPM	5.641E−05	1358
ARSTH4	Air	No	3.75	SLPM	8.059E−05	1936
ARSTH5	Air	No	6.00	SLPM	1.289E−04	3097
ARSTH6	Air	No	1.50	SLPM	3.224E−05	774.3
ARSTH7	Air	No	3.75	SLPM	8.059E−05	1936
ARSTH8	Air	No	1.50	SLPM	3.224E−05	774.3

Run 2A
For device with surfac⑦Cis A Orientation

Run Number	Fluid	Surface-feature	Flow rate	Flow rate units	Mass flow rate (kg/s)	Reynolds number
ARSFG0-45-CISA1-A	Air	Yes	4.88	SLPM	1.048E−04	2519
ARSFG0-45-CISA2-A	Air	Yes	6.00	SLPM	1.289E−04	3097
ARSFG0-45-CISA3-A	Air	Yes	2.63	SLPM	5.641E−05	1358
ARSFG0-45-CISA4-A	Air	Yes	3.75	SLPM	8.059E−05	1936
ARSFG0-45-CISA5-A	Air	Yes	6.00	SLPM	1.289E−04	3097
ARSFG0-45-CISA6-A	Air	Yes	1.50	SLPM	3.224E−05	774.3
ARSFG0-45-CISA7-A	Air	Yes	3.75	SLPM	8.059E−05	1936
ARSFG0-45-CISA8-A	Air	Yes	1.50	SLPM	3.224E−05	774.3

⑦ indicates text missing or illegible when filed

Results:

[0279] The overall length of the channel over which pressures were measured was 6.985". FIG. **9** shows the comparison of experimental pressure drop with and without surface features. As we can see from FIG. **9**, the difference in the overall channel pressure drop between a channel with surface features and a channel without surface features increases with Reynolds Number. "DP Factor" is defined as: DP Factor=pressure drop in channel with surface features/pressure drop in smooth channel. FIG. **10** shows the variation of DP factor with Reynolds number. The overall DP factor as well as well as DP factors in different sections of the channel were calculated. "DP-factor-1-2" means the DP factor between pressure port 1 and 2 (1 being closest to the inlet). From the figure, we can see that near the inlet (between port 1 and 2) the DP factor variation with Reynolds number is relatively flat. The distance between port 1 and 2 is 0.985". After port 2, the DP factor increased sharply with Reynolds number in the laminar regime and flattened out in the transition flow regime. The variation of subsequent DP-factors with Reynolds number (between port 2 and 3, 3 and 4, 4 and 5) was similar to the overall DP factor variation with Reynolds number. It should be noted that the values of DP factor are a function of surface feature design.

[0280] These results show that the increase in pressure drop from the surface feature channels over the flat or smooth channels is a function of the Reynolds number. As the Reynolds number increases, the dP ratio increases from less than 1.5× to more than 2.3×. The pressure drop ratio for the surface feature versus flat channel asymptotes at roughly 2.3× as Reynolds number increases above the laminar region and into the transition and turbulent region. For different surface feature designs, main channel gaps, and fluid properties, the asymptotic value is expected to vary from system to system. These results indicate that the use of surface features may also be beneficial to the enhancement of transition or turbulent flow systems in microchannels, where the increase in pressure drop plateaus with higher Reynolds number, but the net increase in surface area from the surface features may offset the increase in pressure drop. As an example, for a heat exchanger operating in a turbulent flow regime within a microchannel for the preceding example, a surface feature geometry that provides more than 2.3× surface area would give an increase in the overall heat transfer (heat transfer coefficient multiplied by heat transfer area) over the net increase in pressure drop. The net result is a smaller heat exchanger volume for a given duty without an increase in overall pressure drop. The corresponding length of the surface feature microchannel operating in a turbulent regime is likely shorter than a flat microchannel operating in a turbulent regime for similar overall device heat duty.

Example

Modeling of Pressure Drop

[0281] In this example, flow through a microchannel having surface features was modeled using FLUENT. The configuration modeled was SFG0-45 degree angle, trans, and, 10.3 inches in length. The purpose of this modeling activity was to explore the pressure drop for this surface feature device under a variety of conditions. CFD results showed that pressure drop was highly sensitive to surface features, with the pressure drop increasing anywhere from 53% up to 162% over the flat channel, depending on conditions.

The particular surface feature geometry included:

[0282] 45° surface features

[0283] Placed in a TRANS configuration (opposing orientation on top and bottom walls).

[0284] The surface feature depth=0.010 in.; width=0.015 in.

[0285] Surface feature length-wise pitch=0.042 in.

[0286] gap=0.0125 in.

[0287] total width=0.160 in.

[0288] Total length=10.3 in. (0.15 in. upstream and downstream does not include surface features).

[0289] Total number of features=239